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An Evaluation of Procedures Used to Predict Timber Growth and Harvest in the Range and Multiple Resource Interactions Sections of the 1980 RPA Assessment

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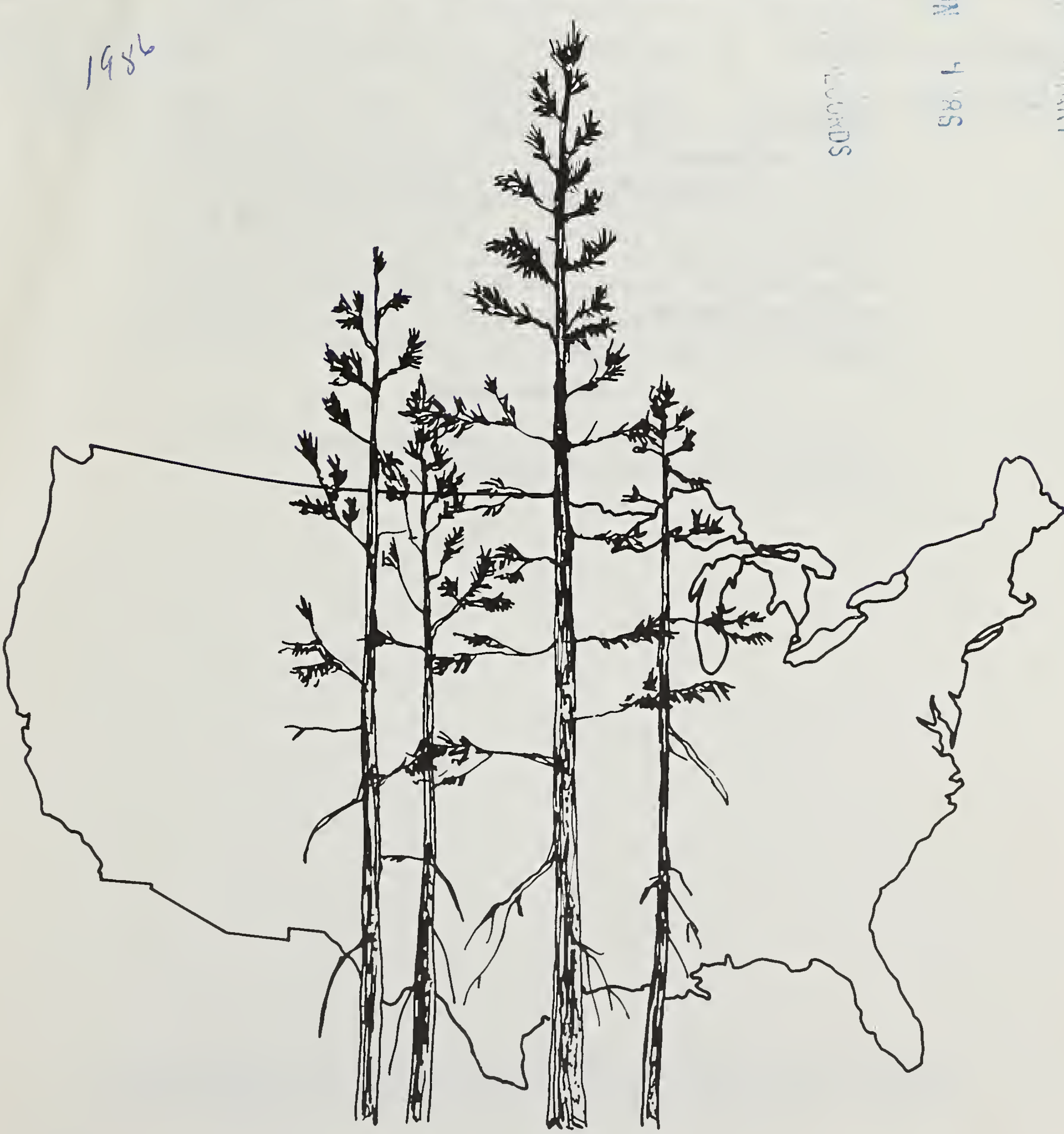

Abstract

Interdisciplinary (ID) team estimates of wood growth and harvest used in the Range and Multiple Resource Interactions sections of the 1980 RPA Assessment were evaluated by checking for the presence of joint resource production estimates, examining data set documentation, and searching for logical and procedural errors. Apparent deficiencies in ID-team training and procedural documentation were found to limit the usefulness of the wood growth and harvest estimates.

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Management Implications

The data set used by the Range and Multiple Resource Interactions chapters of the 1980 RPA Assessment (Forest Service 1980) was developed by interdisciplinary (ID) teams to serve as input to an optimization model. To date, it remains the only existing multiresource data set available encompassing all range and forest lands in the 48 conterminous states of the U.S. This factor has led to considerable interest, both within the Forest Service and from other groups, in using it for applications other than the linear programming model for which it was developed.

This paper evaluates the completeness and reproducibility of the wood growth and yield components of the data set. In addition, some characteristics of the data generation process, especially with reference to the nature of periodic outputs, such as timber harvest, are explained to help ascertain the appropriateness of the data for different applications, and indicate transformations that may be necessary.

The evaluation of the wood growth and yield estimates calls attention to large differences in the quality and reproducibility of estimates by different ID teams. These differences indicate that training of ID teams and their leaders prior to data generation requires additional emphasis.

Introduction

During the past decade, Congress passed laws requiring federal agencies to make recurring assessments of present and projected resources derived from our Nation's forests, rangeland, and agricultural land. The laws assigning assessment responsibilities to the USDA Forest Service are the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA)[2] as amended by the National Forest Management Act of 1976 (NFMA).[3]

In January 1980, the Forest Service published the second comprehensive assessment of the forest and rangeland situation in the United States (USDA Forest Service 1980). The document, in this paper called the Assessment, contained sections on timber, water, range, wildife and fish, recreation, and multiple resource interactions. As part of the sections entitled Range and Multiple Resource Interactions (MRI), a multiresource data set was developed using an intuitive (ID-team) approach.

[2] *Public Law 93-378. United States Statutes at Large. Volume 88, p. 476 (Pub. L. No. 93-378, 88 Stat. 476).*

[3] *Pub. L. No. 94-588, 90 Stat. 2949.*

The procedures involved in producing this multiresource data set have been explained in detail elsewhere (USDA Forest Service 1977, Mitchell and Pickens 1985). Basically, the data set contains estimates for 13 different ecosystem "outputs." Of these, seven pertain to quantifiable resource products: herbage and browse production, net wood growth, wood harvested, domestic livestock grazing, wild ruminant grazing, dispersed recreation use, and water yield. A previous paper evaluated the estimates of herbage and browse production (Mitchell and Pickens 1985).

The purpose of this study was to evaluate the wood harvest and, to a lesser extent, wood growth data contained in the multiresource data set used in the 1980 Assessment. The data structure, discussed below, limits this analysis to various checks of internal consistency and of procedures followed by the ID teams in developing production coefficients.

Description of ID-Team Procedures

The ID-team estimates of these resource outputs were based on a hierarchical partitioning of the forest and range land base of the U.S. according to vegetation classification, land ownership, productivity class (PC), and condition class (CC) (Mitchell and Pickens 1985).

The vegetation classification for timbered and woodland ecosystems was taken from Küchler's (1964) Potential Natural Vegetation system. Several of Küchler's vegetation types were not included (e.g., ponderosa shrub forest, Great Basin pine forest, and juniper steppe woodland) in the Assessment data base, and one nonforested type was added (mountain meadow). Therefore, the amended classification system was renamed Potential Natural Communities (PNC) to mark this distinction.

Ownership criteria were not important for many of the resource outputs. Forage production, for example, on a given site under specified management intensity, should be similar regardless of whether the landowner is the Federal Government or a private citizen. However, such is not the case for timber growth and yield. The Forest Service is restricted by statute in how quickly it can allow trees to be harvested on its lands, while private industry is not. As will be shown later, these differences in rotation length due to land ownership can markedly affect the ID-team estimates for timber growth and harvest. The four owner categories were Forest Service, Bureau of Land Management, other federal, and nonfederal.

Both PC and CC were based on FSH 4809.11 (Forest Survey Handbook). Productivity class referred to the potential productivity of the site for wood growth. Condition class referred to the size category of the dominant trees (table 1).

Therefore, the Nation's land base was divided, prior to the time that the resource production estimates were developed, by PNC, ownership, PC, and CC categories. Each unique PNC-owner-PC-CC combination was termed a resource unit (RU). The RU constituted the basic land management unit the ID teams used in making multiresource production estimates. Because there were four possible outcomes each for ownership, PC, and CC (table 1), each PNC could have a maximum of 64 RUs associated with it.

The 1980 Assessment defined 107 PNCs. Of these, 63 could be classified as being dominated by either timber or woodland species. In this report, 47 of the 63 forested/woodland PNCs were evaluated (table 2). Those eliminated from consideration were not suited to commercial timber management, e.g., pinyon-juniper, mesquite, and mangrove. Production estimates for the western PNCs were developed at two ID-team workshops held at Fort Collins, Colo., while those for eastern PNCs came from comparable workshops at Athens, Ga.

Management options were defined for the Assessment data as a combination of practices describing a specific target management intensity or level (ML) for each of three resource output groups—timber, range, and wildlife (USDA Forest Service 1977). Timber and range both had six possible MLs and wildlife had three (table 3). In general, the MLs selected for each RU had the same options or a subset of the options chosen for that PNC (Mitchell and Pickens 1985). Approximately 10 management triplets were specified for most PNCs. After ML goals were designated, specific timber, range, and wildlife management practices were selected for each RU in order to attain the desired level (table 4). Management practices were chosen to be consistent with technology existing in the mid-1970s.

The ID-team estimates of timber growth and harvest, in relation to the RU-ML framework described above, were based on an intuitive approach. Intuitive models rely on experts to make estimates based on their training and experience, rather than on mechanistic mathematical descriptors or statistical models produced from actual data (Joyce et al. 1983). Such models are increasingly being used where environmental variables are difficult to quantify and where existing research does not provide a full coverage of the options to be considered.

Net wood growth was defined as the annual change in volume of sound wood in trees greater than 5-inches d.b.h., plus the total volume of trees reaching 5-inches d.b.h., less losses due to natural mortality. Wood harvest was defined as the annual removal of wood taken from trees at least 5-inches d.b.h. for use as wood products, excluding that utilized for fuelwood. Wood harvest was assumed to occur from a regulated forest. Both growth and harvest were expressed in units of cubic feet per acre per year (USDA Forest Serivce 1977).

In order to make the timber growth and yield estimates consistent with other parts of the Assessment data set, they were formatted in a manner counterintuitive to most people familiar with timber growth and yield models. The resource output values recorded in the data set were the average production for a RU in a ML. This implies that, after obtaining a value from the relevant growth or yield table for the time period pertaining to the stand's specified CC, a transformation must be applied to convert from total output to annual output within the CC. For timber growth, such a representation is logical; however, it is unusual for harvest because the product generally accrues at one or two points in time. The format was justified because technically no information was lost in the transformation, and it allowed the timber data to accrue in the same way as the other resources, i.e., annually.

The simplified example in table 5 illustrates the idea. Assume the CC transfer, timber growth, and yield information shown. Note that the definition of wood growth precluded growth from occurring until CC3. If commercial thinning is scheduled for pole-sized trees (CC3) under a given timber ML, the value shown in the data base would reflect an intuitive estimate of total removal from the thinning operation divided by the forecast number of years in CC3.

Obviously, entries to a data set using the approach described here would be extremely sensitive to rotation age and the time spent in each CC where harvest occurred. Consequently, the data structure makes it essentially meaningless to attempt a comparison of Assessment estimates obtained by applying composite land base and timber harvest values with field survey data because, in reality, the U.S. land base is not managed with the same MLs and rotations that the Assessment data specify.

The relationship between wood harvest and wood growth may also initially appear unreasonable. Logically, to obtain estimates of yield, the growth function could be integrated up to the harvest age (Clutter 1963). However, this approach implicitly assumes that what is defined as growth is eventually harvested. In the Assessment data base, the definition of growth does not require harvest to occur, so such an assumption may not be true. Growth can only serve as an upper limit to harvest which may or may not be attained.

Methods

The approach used to evaluate the wood growth and harvest component of the Assessment multiresource data set was limited by difficulties associated with its verification or validation—see Nolan (1972) for an explanation of model verification/validation. As outlined above, the growth and yield estimates could not be directly compared with independent survey data.

Another means of verifying the Assessment estimates, i.e., comparison with existing growth and yield tables, was also deemed to be inappropriate. Because the ID-team estimates, themselves, originated from references to growth and/or yield equations, such a task would have amounted to only judging the relative usefulness of various models. It must be assumed that the ID teams, with their familiarity with specific PNCs, selected the most appropriate information sources for timber growth and yield. Moreover, if an ID team generated their estimates without referencing such information sources, the omission should be revealed by some of the logical tests presented below.

Table 1.—Classification categories for timbered and woodland ecosystems used in the 1980 Assessment.

A. Productivity Classes (PC)	B. Condition Classes (CC)
1. 120 + ft^3/acre/yr	1. Nonstocked
2. 85–119	2. Seedlings and saplings
3. 50–84	3. Poles
4. 0–49	4. Sawtimber

Table 2.—List of PNCs from the 1980 RPA Range/Multiple Resource Interaction Assessment evaluated in this report.

Western forests		Eastern forests	
PNC	Name	PNC	Name
1	Spruce/cedar/hemlock	72	Oak savanna
2	Cedar/hemlock/Douglas-fir	73	Oak/hickory/bluestem
3	Silver fir/Douglas-fir	80	Blackbelt
4	Fir/hemlock	82	Cypress savanna
5	Mixed conifer	84	Great Lakes spruce/fir
6	Redwood	85	Conifer Bog
7	Red fir	86	Great Lakes pine
8	Lodgepole pine/subalpine	87	Northeastern spruce/fir
9	Pine/cypress	88	Southeastern spruce/fir
10	Western ponderosa	89	Northern floodplain forest
11	Douglas-fir	90	Maple/basswood
12	Cedar/hemlock/pine	91	Oak/hickory
13	Grand fir/Douglas-fir	92	Elm/ash
14	Western spruce/fir	93	Beech/maple
15	Eastern ponderosa	94	Mixed mesophytic forest
16	Black Hills pine	95	Appalachian oak
17	Pine/Douglas-fir	97	Northern hardwoods
18	Arizona pine	98	Northern hardwoods/fir
19	Spruce/fir/Douglas-fir	99	Northern hardwoods/spruce
20	Southwestern spruce/fir	100	Northeastern oak/pine
24	Mosaic of PNC 2 and Oregon oakwoods	101	Oak/hickory/pine
25	California mixed evergreen	102	Southern mixed forest
		103	Southern floodplain forest
		104	Pocosin
		105	Sand pine scrub

Table 3.—Management levels used in developing the multiresource data base.

Range

A. Environmental management without livestock
B. Environmental management with livestock
C. Extensive management of environment and livestock
D. Intensive management of environment and livestock
E. Environmental management with livestock production maximized
X. Exploitive management

Timber

1. No commercial use
2. Minimal management without assured regeneration
3. Minimal management with assured regeneration
4. Level 3 with commercial thinning
5. Level 4 with precommercial thinning
6. Level 5 plus intensive silviculture such as fertilization

Wildlife

1. No management
2. Manipulation of vegetation
3. Level 2 with physical structure development

Table 4.—Management practices by resource output group used in developing multiresource data set.

Management practice	Units/100 M acres
Range	
Fertilization	M Acres
Irrigation	M Acres
Water control	M Acres
Mechanical vegetation control	
Low cost	M Acres
High cost	M Acres
Vegetation manipulation	
Chemical	M Acres
Biological	M Acres
Fire	M Acres
Debris disposal	M Acres
Mechanical soil treatment	M Acres
Seeding	M Acres
Rodent control	M Acres
Insect and disease control	M Acres
Small water development	Sites
Large water development	Sites
Fence	Miles
Timber thinning	M Acres
Timber	
Planting	M Acres
Direct seeding	M Acres
Site preparation for—	
Natural regeneration	M Acres
Planting and seeding	M Acres
Animal control for—	
Reforestation	M Acres
Timber stand improvement	M Acres
Precommercial thinning	M Acres
Release and weeding	M Acres
Fertilization of established stands	M Acres
Seed production areas	M Acres
Selection and care of superior trees	M Acres
Prescribed burning to control understory	M Acres
Access roads for timber production	Miles
Cutting method	
Shelterwood and seed tree	M Acres
Clearcutting	M Acres
Salvage	M Acres
Selection (high-grading)	M Acres
Selective	M Acres
Wildlife	
Water developments—upland	Sites
Seeding and planting	M Acres
Liming and fertilizing	M Acres
Fencing	Miles
Prescribed burning—uplands	M Acres
Clearing	M Acres
Brush and shrub management	
Mechanical	M Acres
Chemical	M Acres
Biological	M Acres
Pruning	M Acres
Thinning—release	M Acres
Mechanical soil treatment	M Acres
Dens and nest structures	Structures
Perch and nest structures	Structures
Brushpiles and covers	Brushpiles
Streambank stabilizers	Sites

The method selected for evaluating the Assessment wood growth and yield estimates, given the constraints limiting any direct comparisons, centered around a set of seven questions used to describe differences between the estimation procedures for different PNCs and to check for logical discrepancies with the land productivity definitions. In addition, this approach allowed the determination of how complete the data generating process was in relation to the instructions described in the Book of Procedures (USDA Forest Service 1977), and how well the ID teams documented their assumptions in the PNC management scenarios.

The questions used to evaluate the Assessment wood growth and yield estimates are given below, along with the procedures used to address them.

Question 1. What variation existed in timber yield or practices for the same timber ML when different range or wildlife MLs were specified?

One of the past and, possibly, future uses of the Assessment data set is to analyze resource interactions. Question 1 facilitates evaluation of the data set for this purpose by determining whether the ID teams considered the system to be a joint production system in the sense that management actions aimed at production of other outputs affected timber yield or the practices required to get a specific yield.

To evaluate this aspect of the data set, the available MLs for the RUs within a PNC were inspected for the occurrence of one timber ML that occurred with more than one combined range and wildlife ML. For example, timber ML 3 might occur with a range ML of B and a wildlife ML of 1 for one management triplet, and with a range ML of D and a wildlife ML of 1 for some other management triplet.

After comparable management triplets were found, they were evaluated for implicit interactive intent by two tests. First, the timber practices were compared to see if some adjustment was specified, presumably to offset the impact of the management for other resource outputs. Next, the mean annual increment for comparable MLs were calculated and compared.

The following codes were used in recording the results:

N = No comparable data.
1 = The ID team appeared to modify timber practices and/or yields in response to changing range and wildlife MLs.
2 = The ID team did not modify timber practices and/or yields in response to changing range or wildlife MLs.

Question 2. Did the ID teams reference growth and/or yield tables(s) as a basis for their estimates of net wood growth or harvest?

When evaluating intuitive models of wood growth and/or yield, it is valuable to know what tables were used by the ID teams. First, the yield table can be used to check both the logic and calculations supporting their estimates. Second, a determination can be made as to whether these values correspond with the predominant timber species being managed in the PNC, as well as

Table 5.—Example of steps to convert growth and yield table entries to required format.

	CC1	CC2	CC3	CC4
Time in CC (years)	5	15	20	25
Cumulative growth through last year in CC (ft^3)	0	0	4000	7000
Growth within CC (ft^3)	0	0	4000	3000
Annual growth in CC (ft^3)	0	0	200	120
Harvest through last year in CC (ft^3)	0	0	0	7000
Harvest within CC (ft^3)	0	0	0	7000
Annual harvest within CC (ft^3)	0	0	0	280

provide a listing of applied yield tables. Finally, the growth and/or yield tables will include relevant definitions of the output predicted.

Each PNC had a management scenario written for it, as specified in the Book of Procedures (USDA Forest Service 1977). The seven topics comprising the management scenario were physiographic description, endangered species, present land use, land use suitability, productivity, rationale for MLs selected, and management practices. When ID teams referenced timber growth or yield tables, documentation to that effect was contained in the productivity section of the management scenario.

Question 3. Did the management scenario deal with site suitability for timber production?

Once the ID teams obtained (or developed) a potential range of timber growth and yield output values, they then supposedly adjusted these values to correct for specific characteristics of the PNC or to compensate for management practices. From preliminary analyses of the Assessment data base, it became clear that suitability constituted the primary category of correction made. A knowledge of the site suitability criteria applied to each PNC for timber production facilitates evaluation of the calculated wood harvest mean annual increment.

If suitability criteria were considered by the ID teams, they were contained in the management scenario of each PNC. Following are examples of some of the factors that were considered to affect suitability: topography, soils, access, bodies of water, and legal restrictions. To measure how comprehensively the ID teams considered suitability when estimating wood growth and harvest, suitability correction factors for each PNC were categorized into four groups: (1) suitability not mentioned, (2) suitability corrections were for the entire PNC only, (3) suitability corrections varied with PC, and (4) suitability corrections varied with ML within PC.

Question 4. How complete was the timber section of the management scenario relative to the instructions set in the Book of Procedures?

An overall review of completeness would provide an indication of the reproducibility of the ID-team estimates. The estimates referred to here include both management practices as well as net wood growth and harvest. It should be noted that each ID team had members from several disciplines, and each member generally was responsible for one or two scenarios. The individual writing the scenario would naturally be expected to emphasize his or her own resource discipline in this endeavor.

The evaluation of management scenarios was completed in a subjective, but consistent, manner. First, a preliminary review was conducted in order to obtain the range of comprehensiveness represented. After this step, a scale of from 1 to 3 (good, acceptable, minimal) was defined upon which to rate the management scenarios. The scale was based on the quality of information, its presentation, and supporting rationale.

Question 5. Did management scenario indicate any specific timber species managed within the PNC?

This information was essential to evaluate the appropriateness of the growth and yield tables; i.e., if ID team members had, by default, used the indicator species identifying the PNC, definite problems could be expected for those PNCs managed mostly for species not comprising the climax forest communities. Examples of such PNCs include PNC-84 [Great Lakes spruce-fir, which is managed for aspen and birch] and PNC-102 [Southern mixed forest, which is managed for longleaf and slash pine] (Eyre 1980). Although western forests commonly contain large areas of old-growth timber characterizing the PNCs for which they are named, such is more often not the situation. Artifically regenerated Douglas-fir stands have great potential to become increasingly prevalent throughout the Cascade and northern Rocky Mountain ranges, for example (Rehfeldt 1978). In addition, half of the western and more than half of the eastern PNCs are dominated by two or more timber species having different growth characteristics (table 2).

Question 6. Were errors present in the ID-team estimates?

Arithmetic errors in intuitive models are somewhat analogous to coding errors in mathematical models; i.e., searching for errors in coding (logic) tests the interfaces among various model components. Nolan (1972) noted that such a test should be the first step in a model verification/validation process.

The ID-team estimates of wood growth and harvest (mean annual increment) should reflect all corrections, including suitability criteria, time spent in each condition class, and rotation period. Each PNC was spot-checked to ascertain whether calculations built into the ID teams' assumptions actually provided the estimate in the data base.

Question 7. Did the wood growth coefficients appear to be consistent with wood harvest?

Comparison of the net mean annual wood growth with its respective mean annual harvest provided insight into whether the net wood growth coefficients were calculated logically. If the net mean annual wood growth was greater or equal to the wood harvest mean annual increment, then it can be inferred that the ID-team calculations were plausible. However, if the net mean annual wood growth was smaller over the entire rotation period, it can be inferred that the ID teams either made calculation errors or used inconsistent growth and yield tables.

To evaluate wood growth coefficients, net mean annual wood growth for each CC within a PC was computed. These values were then compared to their respective mean annual increments for wood harvest estimates. If the former was greater or equal to the latter, no further evaluation took place. However, if the values for harvest exceeded that for growth, a possible error was inferred, and the CC time periods and net wood growth coefficients were reviewed for noticeable discrepancies.

Results and Discussion

The ID teams varied considerably in how completely they followed procedures and how well documented these procedures were in the various PNC management scenarios. The seven questions are grouped into three categories for discussional purposes; i.e., the multiresource interaction topic (Question 1), data set and procedural documentation (Questions 2, 3, 4, and 5), and presence of logical and/or procedural errors (Questions 6 and 7).

Evaluation of Multiresource Interactions

More than one-half of the 47 PNCs evaluated did not depict an interaction effect (i.e., joint resource production) in response to varying nontimber MLs (table 6).

PNCs from the western (Fort Collins workshops) and eastern (Athens workshops) forests had nearly identical proportions, showing no interaction effect (table 6).

	No. of western PNCs	No. of eastern PNCs
Insufficient MLs	3	4
No interaction	13	14
Interaction	6	7
Total commercial forest PNCs evaluated	22	25

The 13 PNCs showing a resource production interaction effect characterize one attribute of ID-team workshops needing additional emphasis. Of the 12 ID teams meeting at Fort Collins (six teams during each of two sessions), only three accounted for all six western PNCs having an interaction effect. Moreover, just three of the eight Athens ID teams accounted for all seven of the eastern PNCs showing an interaction effect (table 6).

Table 6.—Response of wood harvest and timber management practices to varying range/wildlife MLs in forested PNCs.

PNCs[1] with insufficient MLs to make comparisons

West: 1, 9, 11
East: 82, 88, 104, 105

PNCs showing no interaction effect

West: 2, 4, 5, 6, 10, 12, 13, 15, 17, 18, 19, 20, 25
East: 73, 84, 85, 86, 87, 89, 90, 92, 93, 97, 98, 99, 100, 103

PNCs with an interaction (joint resource production) effect and associated ID teams

	PNC	ID-team Session	
West:	3	3–1	(Fort Collins)
	7	4–1	
	8	4–1	
	14	2–2	
	16	2–2	
	24	3–1	
East:	72	3–1	(Athens)
	80	1–1	
	91	3–1	
	94	1–2	
	95	1–2	
	101	3–1	
	102	1–1	

[1]*See table 2 for PNC identification.*

A logical deduction from these observations is that a few individual ID team members recognized the importance of joint production estimates, and built them into their teams' data sets.

Those groups that did not incorporate joint effects may have believed that nontimber management has no effect on timber production. It appears likely, however, that they either did not consider the possible impact of range and wildlife management practices on timber, or did not feel confident in their ability to make appropriate modifications. Nonetheless, no evidence exists that ID teams were specifically instructed to consider joint resource production as part of the intuitive estimation process.

Only seven PNCs contained insufficient MLs to obtain comparable data. With the exception of Douglas-fir (PNC 11), these were small and contained few timber management levels. The presence of PNC 11 in this group appeared anomalous.

Data Set and Procedural Documentation

Unlike the previous section, which showed no difference between eastern and western PNCs in relation to the question being asked, information concerning data set and procedural documentation was conspicuously dependent upon whether the PNC represented an eastern or western forest.

In general, ID teams dealing with eastern PNCs (Athens workshops) more completely documented their wood production estimates by referencing growth/yield tables (Question 2) and site suitability factors (Question 3). These ID teams additionally provided more complete timber sections of their management scenarios (Question 6), and included references to particular tree species being managed (Question 7). One possible contributing factor may be that, because the eastern workshops were conducted after the western workshops, improved instructions may have been given based on experience gained.

Reference to growth/yield tables.—Twelve of the 22 western PNCs (55%) contained no reference to a growth or yield table in their management scenarios; however, only 5 of the 25 eastern PNCs (20%) fell in this category (table 7). In addition, all of the mangement scenarios having references to more than one growth/yield table were for eastern PNCs. Such a situation probably reflects the greater availability of a variety of growth/yield tables for eastern forests, especially in the Southeast, rather than indicating that ID teams meeting in Athens did a more thorough job.

The problem of lack of references of wood growth/yield tables is somewhat intensified by the incompleteness of several references that were cited. References listed for three of the western PNCs (PNCs 17, 18, and 20) and seven of the eastern PNCs (PNCs 80, 86, 87, 88, 99, 102, and 105) were found to be inadequate to allow them to be acquired in a library search. Of these, only two of the eastern PNC management scenarios contained additional references; for the remainder, the incomplete reference was the only one cited. If the PNCs with all unverifiable references to wood growth/yield tables are included with those containing no reference, then two-thirds and two-fifths of the western and eastern PNCs, respectively, would have been classified as having no references.

Reference to site suitability.—Most of the western PNCs contained some reference to suitability for timber production in their management scenarios, but less than one-half of the eastern PNCs were so categorized (table 8). This was to be expected. Western forests tend to have rugged topography, limited access, fragile soils. and more legal restrictions such as silvicultural restraints in forest practices acts—all factors requiring suitability corrections in the ID-team estimates. However, these factors, and others more prevalent in the East, such as lakes and reservoirs, also affect wood production in eastern forests and probably should have been considered more comprehensively by those ID teams. Again, the results emphasize the requirement for consistent and thorough training of ID teams before the estimation process begins.

Completeness of timber management scenarios.—For the most part, the evaluations of management scenario completeness reflected favorably on the ID teams. Only 3 of the 47 management scenarios examined failed to rate above the minimum acceptable level based on quality of information, its manner of presentation, and supporting documentation (table 9).

Somewhat unexpectedly, the comprehensiveness of management scenarios was not related to ID teams. Each of the six western PNCs rated as good, for example, was written by a different ID team. Six of the eight eastern ID teams were responsible for the eastern PNCs rated as good.

Reference to tree species being managed.—Five of the western and 13 of the eastern PNCs had references to specific tree categories or species when discussing wood growth and yield information (table 10). Examined another way, 13 of the western PNCs, but only 4 of the eastern PNCs, included no reference to either growth/yield tables or key timber species in their management scenarios. Whether a training difference between the Fort Collins and Athens workshops was partly responsible for this disparity cannot be ascertained. ID teams responsible for western PNCs may have incorrectly assumed that the principal timber species characterizing their forests was intuitively obvious.

Logical and Procedural Errors

The wood growth and harvest estimates were, on the whole, free of noticeable errors. In fact, an appraisal of these estimates in terms of Question 4 (Were errors present in the ID team estimates?) turned up no obvious mistakes; i.e., the arithmetic applied for each PNC was done correctly as defined in its management scenario for the values checked. It should be noted, however, that only a few data entries were checked for logical and procedural errors in each PNC.

In regard to Question 5 (Did the wood growth coefficients appear to be consistent with wood harvest?), only a few discrepancies were discovered. Most were small

Table 7.—Categorization of PNCs by number of references to growth and/or yield tables.

PNCs[1] with no reference cited

West: 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 19, 25
East: 72, 82, 89, 101, 104

PNCs with one reference cited

West: 1, 2, 3, 4, 5, 10, 17, 18, 20, 24
East: 73, 80, 84, 91, 98, 99, 102, 103, 105

PNCs with more than one reference cited

East: 85, 86, 87, 88, 90, 92, 93, 94, 95, 97, 100

[1]*See table 2.*

Table 8.—Classification of PNCs[1] in relation to their degree of specificity concerning suitability criteria for timber production.

No suitability criteria mentioned for PNCs

West: 6, 9, 16, 20
East: 82, 84, 86, 90, 91, 92, 93, 94, 95, 97, 98, 99, 104, 105

Suitability criteria applied to PNCs as a whole

West: 7, 8, 10, 11, 12, 14, 15, 17, 18, 24, 25
East: 72, 73, 85, 88, 89, 100, 101, 103

Suitability criteria applied to PC within PNC

West: 1, 2, 3, 4
East: 80, 87, 102

Suitability criteria applied to ML within PC

West: 5, 13, 19

[1]*See table 2.*

Table 9.—Overall rating of PNC timber management scenarios based on quality of information, manner of presentation, and supporting documentation.

PNCs rated as good

West: 5, 10, 13, 14, 19, 20
East: 72, 73, 80, 82, 85, 88, 94, 97, 100, 101, 102, 103

PNCs rated as acceptable

West: 1, 2. 3, 4, 6, 7, 8, 9, 11, 15, 16, 17, 18, 24
East: 84, 86, 89, 90, 91, 92, 93

PNCs rated as minimal

West: 12, 25
East: 87

differences that could, presumably, be attributed to rounding errors when summing across CC. It should be noted that little effort was made by the RPA Range and MRI staffs to validate the wood growth estimates. Different ID teams were suspected to have defined growth differently (e.g., net versus gross wood growth); therefore, corrections applied collectively to all PNCs would have been inappropriate in any case.

Table 10.—Reference to timber species or category managed for wood production by PNC.

	Timber Species/Category
Western PNCs	
2	Douglas-fir
4	Softwoods[1]
5	Softwoods
9	Monterey pine
18	Ponderosa pine
Eastern PNCs	
72	Hardwoods[1]
73	Hardwoods
80	Hardwoods, Softwoods
84	Aspen
85	Softwoods
86	Softwoods
88	Softwoods
89	Cottonwood
90	Sugar maple
98	Hardwoods
102	Softwoods
104	Loblolly pine
105	Sand pine

[1]*Management scenario referred to several species of softwoods/hardwoods or to softwoods/hardwoods, in general.*

Conclusions

Given the newness of ID-team approaches to natural resource problem-solving in 1977, the wood growth and harvest estimates used in the 1980 Range and MRI Assessments were reasonable. Perhaps the most important conclusion to ensue from this study has nothing to do with the wood production estimates per se. Rather, the results have more profound implications on the training of ID teams.

First, all important concepts and terms must be thoroughly defined and emphasized so each team and/or member understands them in the same way. For example, if the significance of joint resource production is construed to be an essential part of the wood growth/harvest data set, it should be properly described and stressed during the training period.

Second, ID teams should comprehensively describe, in writing, all assumptions made and technical methods used in the estimation process. Such documentation becomes imperative if ID-team outputs are to be subject to later verification or evaluation. In addition. citations of all references used must be complete. Holling (1978) has argued that effective communication, which includes descriptions of assumptions and methods, is essential if analyses such as are described in this report are to have an impact on decisionmaking.

Although the data, for the most part, appeared plausible and were moderately well documented, a definite need exists for their complete verification and updating if they are to be used again in national assessments or similar applications. An adequate verification/updating might contain several steps.

1. Development of algorithms (software) to automate the data evaluation. This process would integrate the time period within each CC for a given type of land (PNC-owner-PC combination) with associated management practices and output estimates. This would provide a summary of the management level in a format more familiar to a timber management specialist, the practices applied over a set rotation and the resulting timber growth and yield estimates.

2. A review by qualified timber management specialists of the results of Step 1. Such a review would be conducted on all PNCs to select those needing correction or clarification. Step 2 might reveal changes in Step 1 that would more appropriately present the timber implications for appraisal, thereby making Steps 1 and 2 recursive in nature.

3. Estimation of wood growth and yield for each PNC in need of revision. This step would be performed by appropriate timber management specialists under the supervision of the individual carrying out Step 2. Because only the timber resource would be at issue, the entire ID-team process would not need to be repeated.

Within the updating framework, the timber practices could be modified, but only to the extent of clarifying the intent of the original ID teams. If timber management practices are modified beyond the original ID teams' intents, then the ID-team process should be repeated.

If it is decided that the Assessment data base should be used for applications different from the linear programming framework for which it was developed, some precautions should be considered. First, the potential users must decide whether the data are sufficiently accurate to support their application. Also, users must determine if the data are presented in an appropriate manner, and, if not, whether they can be transformed to a useful form. If, for example, a user is concerned with the timing of harvests, a problem might

arise when the schedule for harvest practices indicates both a thinning and final harvest in CC4. Determining the proportion of volume removed by thinning or the date of thinning is not possible from the practices alone. Such needed information will not always be available in the management scenario.

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Interdisciplinary (ID) team estimates of wood growth and harvest used in the Range and Multiple Resource Interactions sections of the 1980 RPA Assessment were evaluated by checking for the presence of joint resource production estimates, examining data set documentation, and searching for logical and procedural errors. Apparent deficiencies in ID-team training and procedural documentation were found to limit the usefulness of the wood growth and harvest estimates.

Keywords: Timber growth, timber harvest, Resources Planning Act, national assessment, interdisciplinary teams, intuitive models.

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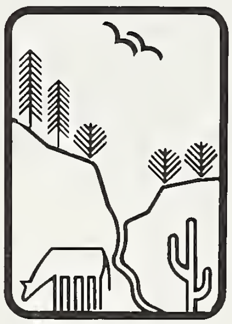
Rocky Mountains



Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

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Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

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Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526